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HASTINGSITES FROM MYSORE

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In the course of his Memoir on "The Charnockite Rocks of Mysore", Mr. B. Rama Rao has recorded the occurrence of several kinds of hornblendes in the charnockitic rocks of Mysore and given in each case, a brief account of their physical and optical properties. According to him, "among the common hornblendes found in charnockite rocks, three distinct varieties may be noticed based on their predominant colour and these are: (*a*) Brown hornblende, (*b*) green hornblende, (*c*) blue or blue green hornblende". In view of their special interest, a more detailed investigation of these amphiboles has now been undertaken by the present writer, and the following paper deals with one of these varieties, *viz*., the "Brown hornblendes" of Mr. B. Rama Rao. The chemical and optical characters of five samples of these "brown hornblendes" have been studied and the results of this investigation are recorded below. The birefringence determinations were made with the Berek's compensator and the measurements of the optic axial angle by means of the Federov's universal stage.

As mentioned by Mr. B. Rama Rao,[1] the brown hornblendes are mostly confined to the basic and ultrabasic types of charnockitic rocks. The five samples under investigation are the following:—

(i) J_2/800: Occurs in a hypersthene-hornblende-biotite peridotite (ultrabasic type) near Arkalvadi, Chamarajanagar taluk.

(ii) N/478: Occurs in a Pyroxenite (ultrabasic type) near south-western edge of the peridotite mass, East of Dodkanya. This rock shows a slighty coarse equi-granular texture—without porphyroblastic hypersthene—and contains a large proportion of hornblendes.

(iii) M_1/782: Occurs in an amphibolite (ultrabasic type) on the eastern flanks of △ 2597 hill range near Hampapur. Here the amphibolite occurs in association with the Kyanite—staurolite—graphite schists, and cutting across them.

(iv) M_2/8: Occurs in a Pyroxene-granulite (Basic type) in the vicinity of Sivasamudram, especially in the region to the west and south-

west of the electrical generating station. Here the granulite occurs as distinct, bouldery, dyke-like runs in the granulitic gneisses of the area, which are found at places to be intersected with aplitic veins and pegmatites.

(v) $M_2/5$: Occurs in a Pyroxene-granulite (Basic type), a mile and a half east southeast on the $\triangle$ 2744 ridge to the west of the Sivasamudram-Malvalli Road. Here the granulite occurs as distinct, bouldery, dyke-like runs in association with bands of quartz ferruginous granulites, sillimanite quartz granulites and finely banded garnetiferous mylonitic gneiss (with a little hypersthene). These bouldery rocks vary from tough spheroidal masses at the northern end of the ridge to schistose types at the southern end.

Optical Characters of the Brown Hornblendes

(i) $J_2/800$.—The brown hornblende occurs as keliphytic borders round coarse plates of schillerised hypersthene, also as independent granular or platey crystals having the characteristic amphibole cleavages.

$Z \wedge C = 12°$ to $15°$, Positive elongation, Negative sign.

Pleochroic scheme

X = Greenish yellow
Y = Yellowish brown $X < Y < Z$
Z = Reddish brown

Refractive Indices

$\alpha = 1 \cdot 665$
$\beta = 1 \cdot 695$ $\gamma - \alpha = \cdot 034$ (Berek's compensator)
$\gamma = 1 \cdot 700$ $2V = 80°$.

(ii) N/478.—The brown hornblende occurs as granular to platey crystals, poikilitic with hypersthene. It is also poikilitic after diopside.

$Z \wedge C = 22°$ to $25°$, Positive elongation, Negative sign.

Pleochroic scheme

X = Greenish yellow
Y = Yellowish Brown $X < Y < Z$
Z = Reddish brown

Refractive indices

$\alpha = 1 \cdot 670$
$\beta = 1 \cdot 690$ $\gamma - \alpha = \cdot 034$ (Berek's compensator)
$\gamma = 1 \cdot 700$ $2V = 81°$

(iii) $M_1/782$.—The brown hornblende is granular along with the felspar, hypersthene and garnet. The brown hornblende is keliphytic with the Pyroxene.

Positive elongation, Negative sign.

Pleochroic scheme

X = Greenish yellow
Y = Yellowish brown $X < Y < Z$
Z = Deep reddish brown

Refractive indices

$\alpha = 1 \cdot 665$
$\beta = 1 \cdot 690$ $\gamma - \alpha = \cdot 034$ (Berek's compensator)
$\gamma = 1 \cdot 700$ $2V = 76°$

(iv) $M_2/8$.—The brown hornblende occurs as scales, laths and granular plates and also poikilitic in hypersthene.

$Z \wedge C = 9°$ to $12°$, Positive elongation, Negative sign.

Pleochroic scheme

X = Greenish yellow
Y = Greenish Brown $X < Y < Z$
Z = Dark (Complete absorption for Z)

Refractive indices

$\alpha = 1 \cdot 675$
$\beta = 1 \cdot 695$ $\gamma - \alpha = \cdot 025$ (Berek's compensator)
$\gamma = 1 \cdot 700$ $2V = 78°$

(v) $M_2/5$.—The brown hornblende occurs as laths and granular plates and also poikilitic in hypersthene.

$Z \wedge C = 9°$ to $12°$, Positive elongation, Negative sign.

Pleochroic scheme

X = Greenish yellow
Y = Yellowish brown $X < Y < Z$
Z = Dark (complete absorption for Z)

Refractive indices

$\alpha = 1 \cdot 680$
$\beta = 1 \cdot 695$ $\gamma - \alpha = \cdot 021$ (Berek's compensator)
$\gamma = 1 \cdot 700$ $2V = 81°$ (Birefringence method)

Chemical Constitution of Hornblendes

The brown hornblendes mentioned above were separated by the usual methods and pure samples obtained. They were then chemically analysed and the analyses are given below.*

TABLE I

	$J_2/800$	N/478	$M_1/782$	$M_2/8$	$M_2/5$
SiO_2 ..	39·02	38·98	42·30	38·58	39·86
Al_2O_3 ..	11·85	13·96	15·68	12·01	13·97
Fe_2O_3 ..	3·96	3·35	2·86	4·93	3·62
FeO ..	9·23	9·59	8·23	13·21	14·71
MgO ..	17·62	14·88	13·92	11·38	10·78
CaO ..	11·42	9·82	12·81	9·62	9·31
Na_2O ..	3·17	4·49	2·20	3·34	2·92
K_2O ..	0·63	0·58	0·56	1·12	0·98
H_2O^+, H_2O^- ..	0·34	1·82	0·98	0·68	0·52
MnO ..	0·29	0·38	0·42	0·79	0·61
TiO_2 ..	1·48	1·63	1·56	4·02	2·35
	99·09	99·48	101·52	99·68	99·63

In order to obtain the empirical formulæ of the brown hornblendes, the metal atoms were calculated from the molecular proportions (Table II).

TABLE II

Chart showing the ratio of metal atoms to its corresponding oxygen ratio

	$J_2/800$		N/478		$M_1/782$		$M_2/8$		$M_2/5$	
	No. of metal atoms	No. of oxygen atoms	No. of metal atoms	No. of oxygen atoms	No. of metal atoms	No. of oxygen atoms	No. of metal atoms	No of oxygen atoms	No. of metal atoms	No. of oxygen atoms
SiO_2 ..	0·650	1·300	0·650	1·300	0·705	1·410	0·643	1·286	0·664	1·328
TiO_2 ..	0·019	0·038	0·020	0·040	0·020	0·040	0·050	0·100	0·029	0·058
Al_2O_3 ..	0·234	0·351	0·274	0·411	0·308	0·462	0·236	0·354	0·254	0·381
Fe_2O_3 ..	0·050	0·075	0·042	0·063	0·036	0·054	0·062	0·093	0·046	0·069
FeO ..	0·128	0·128	0·133	0·133	0·114	0·114	0·183	0·183	0·204	0·204
MgO ..	0·441	0·441	0·372	0·372	0·348	0·348	0·284	0·284	0·269	0·269
MnO ..	0·004	0·004	0·006	0·006	0·006	0·006	0·011	0·011	0·008	0·008
CaO ..	0·204	0·204	0·175	0·175	0·229	0·229	0·171	0·171	0·166	0·166
Na_2O ..	0·104	0·052	0·146	0·073	0·070	0·035	0·106	0·053	0·094	0·047
K_2O ..	0·012	0·006	0·012	0·006	0·012	0·006	0·024	0·012	0·022	0·011
H_2O^+, H_2O^- ..	0·034	0·017	0·200	0·100	0·108	0·054	0·078	0·039	0·056	0·028
	1·880	2·616	2·030	2·679	1·956	2·758	1·848	2·586	1·812	2·569

* Analyst:—E. R. Tirumalachar.

The empirical formulæ were calculated from the ratio of the metal atoms to its corresponding oxygen ratio.

The formulæ for the five minerals are as follows (Table III):—

TABLE III

$J_2/800$ ..	$Ca_2\ Na\ (Mg, Fe, Mn)_6\ Al\ (Al_2\ Si_6)\ O_{24}$
$N/478$ ..	$H_2\ Ca_2\ Na\ (Mg, Fe, Mn)_4\ Al\ (Al_2\ Si_6)\ O_{24}$
$M_1/782$ ..	$H\ Ca_2\ Na\ (Mg, Fe, Mn)_4\ Al\ Si\ (Al_2\ Si_6)\ O_{24}$
$M_2/8$ ..	$H\ Ca_2\ Na\ (Mg, Fe, Mn)_4\ Al\ Si\ (Al_2\ Si_6)\ O_{24}$
$M_2/5$ ..	$H\ Ca_2\ Na\ (Mg, Fe, Mn)_4\ Al\ Si\ (Al_2\ Si_6)\ O_{24}$

Conclusion

The formulæ of these hornblendes are compared with that given by Larsen and Berman[2] for hastingsites. Except in the case of N/478, the formulæ do not exactly coincide with that given by Larsen and Berman. $J_2/800$ is anhydrous and the (Mg, Fe) atom is in excess. In $M_1/782$ the hydrogen molecule is just half and the silicon atom is in excess by one. The same character is found in $M_2/8$ and $M_2/5$. The deficiency of hydrogen is perhaps due to the dry nature of the charnockite magma, a character that has been noticed both by Sir Thomas Holland and Dr. A. W. Groves.[3]

The hastingsites have been worked in greater detail by M. Billings[4] who, on a detailed study of the chemistry, optics and genesis of the hastingsite group, comes to the conclusion that they can be classified into three types, ferro-hastingsite, femag-hastingsite and magnesio-hastingsite. For this classification, he utilises the FeO/MgO ratio. If FeO/MgO exceeds two, the mineral is ferro-hastingsite; if FeO/MgO is less than two, but greater than one-half, the mineral is femag-hastingsite; if FeO/MgO is less than one-half, the mineral is magnesio-hastingsite. By this criteria, the Mysore hastingsites can be classified as follows (Table IV):—

TABLE IV

$J_2/800$	From ultra-basic types	FeO/MgO = ·3	Magnesio-hastingsite
$N/478$		FeO/MgO = ·4	Magnesio-hastingsite
$M_1/782$		FeO/MgO = ·3	Magnesio-hastingsite
$M_2/8$	From basic types	FeO/MgO = ·7	Femag-hastingsite
$M_2/5$		FeO/MgO = ·8	Femag-hastingsite

The brown hornblendes occurring in the basic types of charnockites are Femag-hastingsites while those from the ultrabasic types are Magnesio-hastingsites.

Hastingsites have been studied in India by K. K. Mathur and A. G. Jhingran.[5] For comparison, one of the analyses of the brown hornblendes

is set here along with that for Girnarite, described by the abovementioned authors (Table V).

TABLE V

	Girnarite	N/478
SiO_2 ..	34·67	38·98
Al_2O_3 ..	13·30	13·96
Fe_2O_3 ..	10·06	3·35
FeO ..	14·77	9·59
MgO ..	6·21	14·88
CaO ..	10·58	9·82
Na_2O ..	5·78	4·49
K_2O ..	1·08	0·58
H_2O^+ H_2O^- ..	0·03	1·82
MnO ..	0·27	0·38
TiO_2 ..	2·88	1·63
P_2O_5 ..	1·08	..
Total ..	100·71	99·48

The variation between the two analyses consists in the fact that iron oxide is far in excess of magnesia in Girnarite. The lime ratio to magnesia is far in excess in Girnarite whereas in the hastingsites here studied, magnesia is always in excess of lime. The ratio of the alkalies to lime and of soda to potash is in excess in Girnarite to the corresponding ratios in the Mysore hastingsites. Mathur and Jhingran therefore have classified Girnarite as an alkali-hastingsite whereas the Mysore hastingsites have no alkalic affinities and are related to an ultramafic magma of the normal pacific suite of rocks.

Dr. A. W. Groves[6] has proposed that the chemical composition of amphiboles and pyroxenes can be expressed in formulæ consistent with the latest X-ray work on the structure of amphiboles and pyroxenes. The method of calculation in the case of amphiboles assumes for a basis the tremolite structure as investigated by X-ray and expresses the ratio of the metal atoms to the oxygen ratio in any other amphibole in terms of tremolite. Adopting Grove's method, the chemical composition of Mysore hastingsites were cast in the form of the tremolite structure. The data for this calculation is given in the accompanying chart (Table VI). The formulæ by this method are as follows:—

$J_2/800$: $(OH)_{.31}\,(Ca, Na, K)_{2\cdot9}\,(Mg, Fe, Mn, Ti, Al)_{5\cdot99}\,(Si, Al)_{8\cdot00}\,O_{22}$

$N/478$: $(OH)_{1\cdot8}\,(Ca, Na, K)_{2\cdot99}\,(Mg, Fe, Mn, Ti, Al)_{5\cdot42}\,(Si, Al)_{8\cdot00}\,O_{22}$

$M_1/782$: $(OH)_{.98}\,(Ca, Na, K)_{2\cdot74}\,(Mg, Fe, Mn, Ti, Al)_{5\cdot60}\,(Si, Al)_{8\cdot00}\,O_{22}$

$M_2/8$: $(OH)_{.72}\,(Ca, Na, K)_{2\cdot83}\,(Mg, Fe, Mn, Ti, Al)_{5\cdot65}\,(Si, Al)_{8\cdot00}\,O_{22}$

$M_2/5$: $(OH)_{.26}\,(Ca, Na, K)_{2\cdot80}\,(Mg, Fe, Mn, Ti, Al)_{5\cdot80}\,(Si, Al)_{8\cdot00}\,O_{22}$

TABLE VI

J₂/800

	Percent by weight	No. of mol.	No. of (O, OH, F)	No. of metals (OH, F)	
SiO_2 ..	39·02	0·650	1·300	5·96	8·00
Al_2O_3 ..	11·85	0·117	0·351	2·15 (2·04 / 0·11)	
TiO_2 ..	1·48	0·019	0·038	0·17	5·99
Fe_2O_3 ..	3·96	0·025	0·075	0·46	
FeO ..	9·23	0·128	0·128	1·17	
MgO ..	17·62	0·441	0·441	4·04	
MnO ..	0·29	0·004	0·004	0·04	
CaO ..	11·42	0·204	0·204	1·87	2·93
Na_2O ..	3·17	0·052	0·052	0·95	
K_2O ..	0·63	0·006	0·006	0·11	
H_2O^+ / H_2O^- ..	0·34	0·017	0·017	0·31	0·31
			2·616 24/2·616 = 9·17		

N/478

	Percent by weight	No. of mol.	No. of (O, OH, F)	No. of metals (OH, F)	
SiO_2 ..	38·98	0·647	1·294	5·81	8·00
Al_2O_3 ..	13·96	0·137	0·411	2·46 (2·19 / 0·27)	
TiO_2 ..	1·63	0·020	0·040	0·18	5·42
Fe_2O_3 ..	3·35	0·021	0·063	0·38	
FeO ..	9·59	0·133	0·133	1·20	
MgO ..	14·88	0·372	0·372	3·34	
MnO ..	0·38	0·006	0·006	0·05	
CaO ..	9·82	0·175	0·175	1·57	2·99
Na_2O ..	4·49	0·073	0·073	1·31	
K_2O ..	0·58	0·006	0·006	0·11	
H_2O^+ / H_2O^- ..	1·82	0·100	0·100	1·80	1·80
			2·673 24/2·673 = 8·98		

M₁/782

	Per cent by weight	No. of mol	No. of (O, OH, F)	No. of metals (OH, F)	
SiO_2 ..	42·30	0·701	1·402	6·12	8·00
Al_2O_3 ..	15·68	0·154	0·462	2·69 (1·88 / 0·81)	
TiO_2 ..	1·56	0·020	0·040	0·17	5·60
Fe_2O_3 ..	2·86	0·018	0·054	0·32	
FeO ..	8·23	0·114	0·114	1·20	
MgO ..	13·92	0·348	0·348	3·04	
MnO ..	0·42	0·006	0·006	0·06	
CaO ..	12·81	0·229	0·229	2·00	2·74
Na_2O ..	2·20	0·035	0·035	0·62	
K_2O ..	0·56	0·006	0·006	0·12	
H_2O^+ / H_2O^- ..	0·98	0·056	0·056	0·98	0·98
			2·752 24/2·752 = 8·73		

M₂/8

	Per cent by weight	No. of mol.	No. of (O, OH, F)	No. of metals (OH, F)	
SiO_2 ..	38·58	0·643	1·286	5·97	8·00
Al_2O_3 ..	12·01	0·118	0·354	2·20 (2·03 / 0·17)	
TiO_2 ..	4·02	0·050	0·100	0·46	5·65
Fe_2O_3 ..	4·93	0·031	0·093	0·58	
FeO ..	13·21	0·183	0·183	1·70	
MgO ..	11·38	0·285	0·285	2·64	
MnO ..	0·79	0·011	0·011	0·10	
CaO ..	9·62	0·171	0·171	1·64	2·83
Na_2O ..	3·34	0·053	0·053	0·98	
K_2O ..	1·12	0·012	0·012	0·21	
H_2O^+ / H_2O^- ..	0·68	0·039	0·039	0·72	0·72
			2·587 24/2·587 = 9·28		

M₂/5

	Per cent. by weight	No. of mol.	No. of (O, OH, F)	No of metals (OH, E)	
SiO_2 ..	39·86	0·664	1·328	6·125	8·00
Al_2O_3 ..	13·97	0·137	0·411	2·532 (1·875 / 0·657)	
TiO_2 ..	2·35	0·030	0·060	0·276	5·802
Fe_2O_3 ..	3·62	0·023	0·069	0·424	
FeO ..	14·71	0·204	0·204	1·881	
MgO ..	10·78	0·270	0·270	2·490	
MnO ..	0·61	0·008	0·008	0·074	
CaO ..	9·31	0·166	0·166	0·867	2·799
Na_2O ..	2·92	0·047	0·047	0·203	
K_2O ..	0·98	0·011	0·011	1·729	
H_2O^+ / H_2O^- ..	0·52	0·028	0·028	0·258	0·258
			2·602 24/2·602 = 9·224		

For comparison, an analysis of hornblende from the charnockites of Uganda[7] (S. 343) is given below.

S. 343 (*Hornblende from the Charnockites of Uganda*)

TABLE VII

	Per cent. by weight	No. of mol.	No. of (O, OH, F)	No. of metals (OH, F)	
SiO_2 ..	37·79	0·630	1·260	5·90	8·00 (5·90 + 2·10)
Al_2O_3 ..	11·92	0·117	0·351	2·19 {2·10, 0·09}	
TiO_2 ..	3·37	0·043	0·086	0·40	5·33 (0·09 + 0·40 + 0·80 + 2·08 + 1·96)
Fe_2O_3 ..	6·78	0·043	0·129	0·80	
FeO ..	15·99	0·222	0·222	2·08	
MgO ..	8·37	0·209	0·209	1·96	
MnO ..	..	..	..	..	
CaO ..	9·76	0·174	0·174	1·63	2·68 (1·63 + 0·43 + 0·62)
Na_2O ..	1·38	0·023	0·023	0·43	
K_2O ..	3·08	0·033	0·033	0·62	
H_2O^+ / H_2O^- ..	1·56	0·076	0·076	1·42	1·42
	100·00		2·563 24/2·563 = 9·36		

S. 343: $(OH)_{1\cdot42}\,(Ca, Na, K)_{2\cdot68}\,(Mg, Fe, Mn, Ti, Al)_{5\cdot33}\,(Si, Al)_{8\cdot00}\,O_{22}$ (Uganda)

N/478: $(OH)_{1\cdot8}\,(Ca, Na, K)_{2\cdot99}\,(Mg, Fe, Mn, Ti, Al)_{5\cdot42}\,(Si, Al)_{8\cdot00}\,O_{22}$ (Mysore)

Though both correspond in tremolite structure, the ratio of FeO to MgO is far in excess in the Uganda hornblende, whereas in the Mysore hastingsite MgO is consistently far in excess of FeO. The chemical composition of Uganda hornblende is here cast into the hastingsite formula. For comparison, is also given the hastingsite formula of N/478.

S. 343 (Uganda): $H_2Ca_2\,Na\,(Mg, Fe)_4\,Al\,(Al_2\,Si_6)\,O_{24}$

N/478 (Mysore): $H_2\,Ca_2\,Na\,(Mg, Fe, Mn)_4\,Al\,(Al_2\,Si_6)\,O_{24}$

The two formulæ correspond except that the ratio of MgO to FeO varies as indicated above. According to the criteria given by Billings, the hornblende of the charnockites of Uganda is Femag-hastingsite and corresponds to the Femag-hastingsites occurring in the basic types of the charnockitic rocks of Mysore.

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ALGAL STRUCTURES FROM THE CUDDAPAH LIMESTONES (PRE-CAMBRIAN), S. INDIA

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Introduction

IN a communication published more than five years ago, the author (Rao, 1943) reported the occurrence of certain peculiar structures from the limestones of the Cuddapah formation (Pre-Cambrian) of South India; and in a later communication (Rao, 1944) gave a short description of the same, leading to the conclusion that they represented primitive and undescribed algal forms. Since then, in a series of visits to the field, more of this interesting material has been collected which on detailed investigation has revealed the presence of numerous forms which appear to be structurally more advanced than the types described so far; and at least in one case what looks like a primitive cellular structure has been identified. This discovery is of considerable importance in tracing the nature of the most primitive forms of plant life that lived during the earliest period of the history of the Earth.

Ever since the discovery of certain 'Algal forms' by Dr. Walcott (1914) from the Pre-Cambrians of North America, geologists and palæobotanists have been searching similar beds in other parts of the world for undoubted evidence of life. In several places, specially Australia, forms similar to those described by Walcott have been found; but on account of the lack of recognisable cellular structures, palæobotanists in particular have hesitated to accept them as true remains of algal life. Some of them like Seward (1933) are not prepared to accept anything less than actual cell structure as correct and true evidences of algal remains. But it is an important point to consider whether in studying delicate organic structures, from such ancient and remote periods such as the Pre-Cambrians, it is reasonable to insist upon the visible persistence of the minute cellular structures in recognising the organic character of these remains. As Marshall Howe (1932) says "The individuals are of microscopic size and individuality is often poorly defined, but the colonial masses of the present age are commonly of macroscopic dimensions, and in the geologic past such masses apparently helped

to make deposits of lime, that are now conspicuous features of extensive geologic formations. It is to be freely conceded, however, that no one of these supposed algal limestones of Cambrian or Pre-Cambrian age, when examined microscopically either decalcified, or in ground sections shows any incontestable evidences of algal nature. In view of the extensive age of these supposed plants, and the extreme delicacy of the gelatinous cell walls of the Myxophyacæ, even when more or less calcified, it seems unreasonable to expect any preservation of their microscopic cell structure." Sir Douglas Mawson and C. T. Madigan (1930) have made similar observations in connection with the appearance of primitive algæ under the microscope. "Thin slices examined under the microscope do not generally exhibit distinct internal structures. The calcium carbonate of the fossil forms is usually fine-grained and exhibits an evenness and regularity not present in the general limestone of the base of the country rock."

Recently J. H. Johnson (1943) in his Bibliography of calcareous algæ has attempted to classify for purposes of easy identification the whole group of algæ. In this connection he has shown that the Cyanophyta or blue green algæ rarely show any cellular structure; and that their identification is mostly by external shape and form. Similarly Mawson (1929) in discussing the algal limestones forming at the present time in certain regions near South Australia makes the following important observation regarding the internal structure of these limestones. "These structures are usually solid throughout, but, often, when opened up, exhibit an irregular cavernous interior. When viewed in thin slices under the microscope, there is observable no distinct and characteristic cell structure such as one might expect from petrifaction of organic origin. Even certain species of undoubted Lithothamnium showed no conspicuous cell structure when these limestones were examined under the microscope."

In view of the above statements, it is clear that certain structures from ancient limestones have been regarded by a number of workers as due to activities of primitive plants, although a cellular structure as such is not actually observed under the microscope. In judging the character of such very ancient and delicate structures, it appears reasonable to take the sum-total of the characters noticed and assess their indications and significance in coming to a conclusion. While it is true that a cellular structure is undoubtedly the most convincing evidence of a true fossil, yet the importance of other features under the known circumstances should not be minimised. The constancy of occurrence in the field and the uniform structures exhibited by the individuals are matters of the utmost importance and worthy of serious consideration.

Description of the Limestones and the Algal Forms contained in them

The lower Cuddapah formation in South India consists of Papugnee at the base and Cheyair at the top. From the point of view of this paper, it is the Cheyair formation which is of importance. It consists of shales and limestones, with interbedded basic igneous rocks. The formation is of wide extent and attains its maximum thickness almost at its middle portion, where it forms a wide belt, dipping uniformly eastwards at an angle of 25° to 30°.

The limestones are usually dark, but sometimes show a buff or pink colour. These limestones occur in bands, one overlying the other. About two and half miles N.N.E. of Royalcheruvu (Ananthapur District) are noticed a series of such bands running parallel to one another. The thickness of these bands varies from 30 to 100 feet. These limestone bands have been traced over a distance of about four miles along the general strike direction N.N.W. and S.S.E.

The central band of a dark coloured limestone is rather peculiar and strikes as somewhat different from the rest of the limestones of the locality. Its comparative hardness and slightly bluish appearance indicates a more magnesian variety than the other limestones of the area.

The surface of this limestone has developed peculiarly striking structures, which on close and detailed study has revealed very interesting features. They are large, often, rounded structures which are more than 20 to 40 feet in dimension, generally showing an elevated surface (Plate III, Fig. 1) from the rest of the ground level. Such structures are found in plenty, and they often show a linear arrangement. Each of such areas is separated from the adjacent ones by the ordinary massive variety of limestone. A careful study of one such structure showed the presence of numerous rounded or ovoidal patches separated by reddish brown highly calcareous mud often ranging in thickness from half to one and half inches. These patches are more than a foot in diameter. A detailed examination of such bodies has shown that it represents a crowded colony of algal development. It is made up of individuals two to five inches in length and an inch to inch and a half in diameter. These individuals are conical in shape with the broad end at the top and pointing downwards with a tapering edge. At the top, the individuals appear to be separate and distinct, but at the base they are fused together. These individuals show distinct lines of growth which are generally concave in habit. They are very narrow at the base, and become wider and wider at the top. When the specimen is polished, it reveals an exceedingly fine porcellanoidal appearance which is very typical of algal

limestones. Under the microscope it reveals parallel bands, often showing bulgings and protuberances characteristic of algal development. There is a distinct difference between the main mass of the limestone and these parallel bands which are algal in origin. The former is coarse-grained and irregular, whereas the latter bands due to plant activity are regular, fine-grained and exhibit an evenness which is very striking under the microscope (Plate III, Fig. 2), and is suggestive of a primitive cell structure. Such a structural development has also been observed by Sir Douglas Mawson and C. T. Madigan (1930). From this it is possible to infer that the most primitive variety showed no differentiation of structure. Such a primitive development of nodular or cylindrical forms have been termed *Cryptozoon* from different parts of the world.

Intimately associated with the cryptozoon limestone described above and forming part of the rock, we get a dark and fine-grained limestone which shows interesting structures. When a thin slice of this limestone is examined under the microscope it shows that it is partly oolitic in texture; but apart from these oolites there are other bodies showing certain structural features which are certainly not due to inorganic agencies. From a careful study of these bodies, one can easily classify them under the following types. (1) Encrusting, (2) Annular, (3) Filamentous and tubular and (4) Branching.

(1) *Encrusting type*.—This is the most abundant type and also appears to be the most primitive variety, showing definite algal structures. In hand specimens the rock looks hard and compact with a rugged appearance on the surface. But when the specimen is polished, it shows numerous colourless or white elongated patches, often tapering on either ends, and looks opaque and porcellanoidal. These patches on the dark groundmass of the limestone gives a very characteristic appearance.

Under the microscope (Plate I, Fig. 1) it shows a peculiar structure. It occurs as longitudinal bands very different from the irregular limestone mass of the rock. Its granularity is well defined, and is more fine-grained than the main mass of the limestone; oftentimes, it shows bulgings and protuberances indicating a special development at certain points. Low power examination indicates that the individual calcite grains are most often uniform; and high power observation reveals that those uniform grains of calcite have been precipitated on previously existing limestone. In sections these show peculiar shapes (Plate I, Figs. 1 and 2) suggestive of algal origin. Such precipitated algal limestones probably represent the original thallus which developed in horizontal layered masses encrusting the previously existing limestone.

(2) *Annular types.*—Next in abundance are the annular bodies which occur in very large numbers and are the most conspicuous structures in several of the microslides. They are of different sizes, some of them are as big as ·25 of a millimetre in diameter and others are much smaller. At first sight they look like ordinary oolitic grains, but a closer examination has shown that, whereas the oolites are clear and show regular concentric arrangement of layers, these annular bodies are made up of two layers concentric with each other and situated very near the circumference, and the central portion being invariably hollow. In the case of the associated oolites the central portion shows an inorganic nucleus. On account of its remarkable similarity with the cross-sections of the thallus of Dasycladaceæ it was described as such in an earlier paper (Rao, 1943) (Plate I, Fig. 2).

(3) *Filamentous and tubular types.*—These can be divided into two minor subdivisions, (*a*) Solid filamentous bodies and (*b*) Hollow tubular structures. (*a*) The solid filamentous bodies are of various sizes and diameters. They are slightly darker than the rest of the rock mass due to closer aggregation of granules of calcite. They always show tapering ends. They occur crowded and cross one another at various angles. (*b*) The hollow tubular structures are rather rare, but are of considerable interest. They show hollow cylindrical outlines, and both cross and longitudinal sections are found in plenty. In cross-sections they are rounded and show a faint trace of a cell wall very near the circumference, and the central portion is hollow. The longitudinal sections on the other hand are more or less rectangular in outline, with a distinct but a thin cell wall and the central portion is again hollow. Both of them suggest that the species is a long tapering tubular body.

(4) *Branching type.*—The last one, namely, the branching type, is the most interesting from the morphological point of view. It is unlike any of the types described so far, and is the nearest approach to the later types of undoubted algæ. This variety is rather rare, but one of the best types studied has been photographed (Plate II, Fig. 1). It is a long and filamentous body about half an inch in length, and is clearly visible to the naked eye in the slide. When examined under the microscope, it shows the most primitive types of morphological differentiation in the development of definite dichotomous type of branching at the ends. A close examination of the specimen shows that there are distinct partitions parallel to the length and also cross partitions clearly suggestive of cell walls.

Summary

For some time past the author has been making a detailed petrographic study of the Pre-Cambrian rocks so extensively and typically developed in the Ananthapur, Cuddapah and Kurnool districts of the Madras Presidency. During the course of this work, the limestones occurring near Royalchervu (Ananthapur District) have revealed certain peculiar structures. From a detailed study of these, and their comparison with similar forms described elsewhere, the author strongly feels that these structures from the Cuddupah limestones which are so striking and persistent, and possess such strong resemblances to primitive 'Algal forms' described from other parts of the world that they deserve serious and full consideration for being recognised as true fossils. Further work on this interesting material is in progress; in the meanwhile the author will be grateful to have the considered views of competent specialists in this fascinating field of study—'Pre-Cambrian Life'.

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FIG. 1. Distinct arrangement of calcite in the longitudinal body showing protuberances and bulgings. Also numerous cylindrical bodies.

FIG. 2. Annular sections showing cell wall like structure near the circumference and a hollow interior ×25

FIG. 1. Branching type and annular bodies in a matrix of calcite. ×25

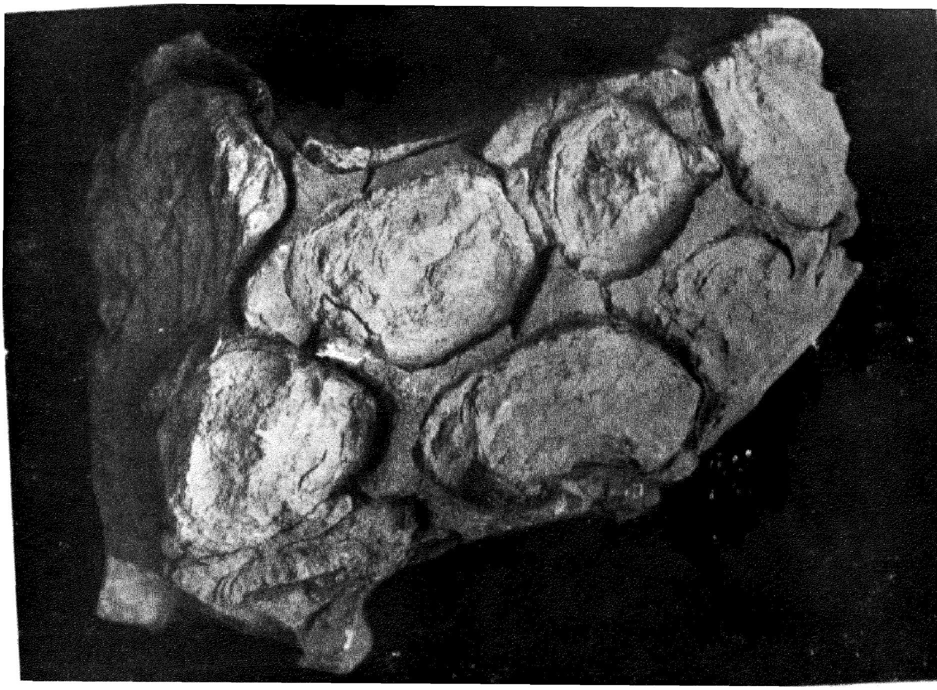

FIG. 1. Colonial forms resembling Cryptozoon. Top view. About ½ the natural size

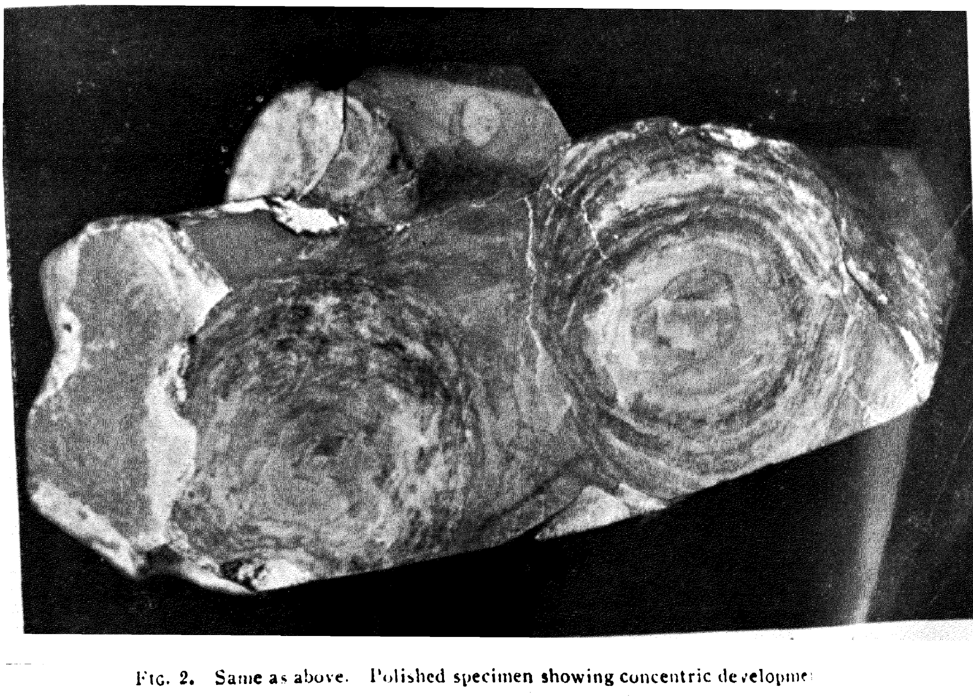

FIG. 2. Same as above. Polished specimen showing concentric developme

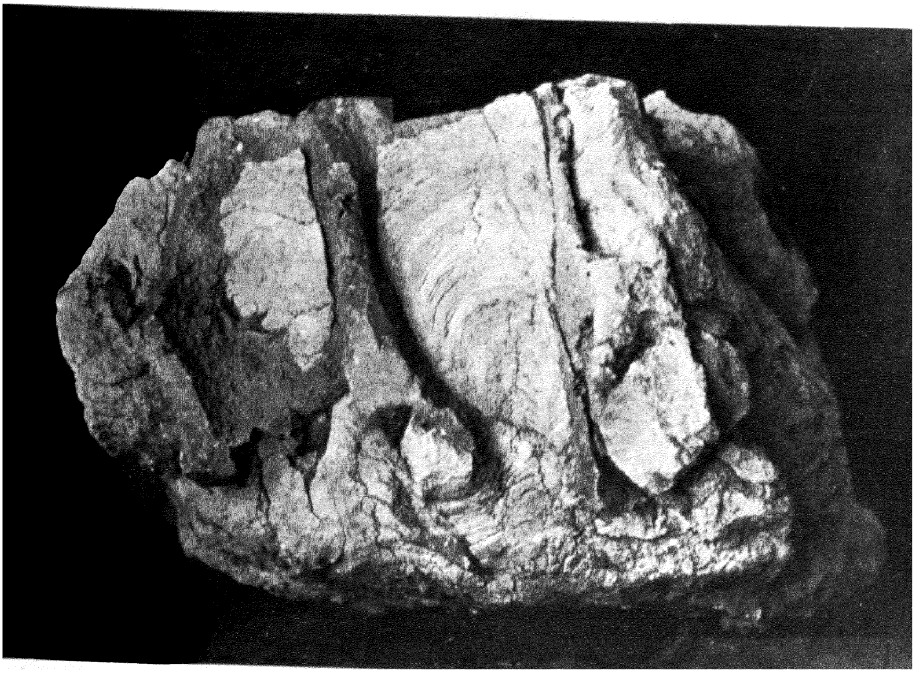

FIG. 1. Colonial forms. Side view. Cylindrical bodies showing concave lines of growth and tapering ends. About ½ the natural size

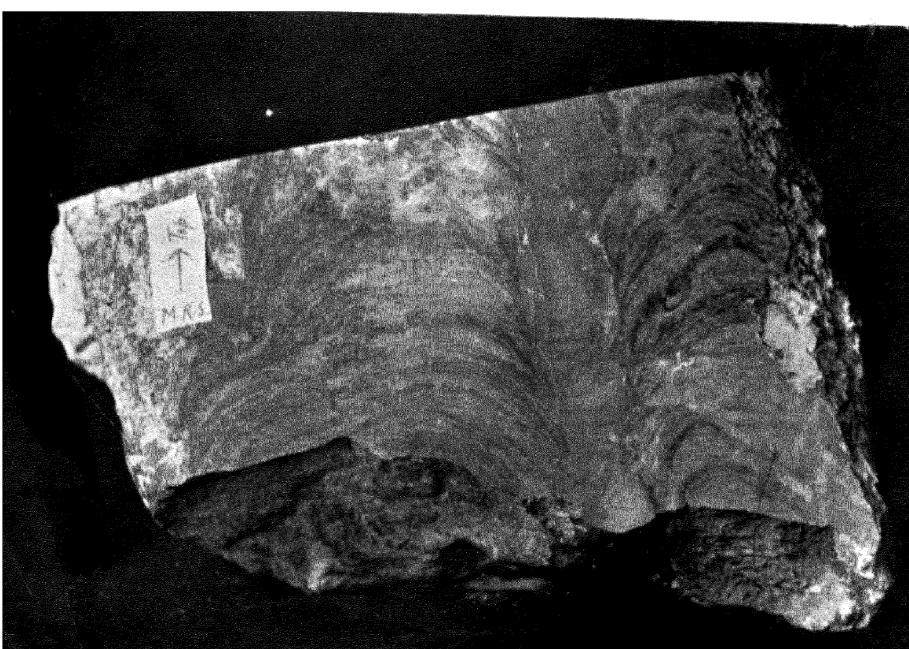

FIG. 2. Same as above. Polished specimen. Shows porcellanoidal patches and concave lines of growth. About ½ the natural size

CONTRIBUTIONS TO THE FLORA OF NANDI HILLS

Part II. Additions to the Common Flowering Plants of Nandi Hills

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SINCE the publication of "Some Common Flowering Plants of Nandi Hills", and "Some Interesting Rusts and Smuts" (of Nandi Hills) (Thirumalachar, *et al.*, 1942 *a*, *b*), further collections were made and studied. In this paper brief descriptions of the flowering plants that were not given in the previous accounts are included.

Sincere thanks are due to Prof. L. N. Rao for kind encouragement and help, and also to the Systematic Botanist, Coimbatore, for determining some of the species included here.

1. PIPERACEÆ.

Peperomia sp., a herb with emarginate leaves, and slender spikes, upto 0·75 inch long; grows in rocky places where moisture is collected.

2. ULMACEÆ.

Celtis tetrandra Roxb., a small tree with grey bark, and serrate leaves, and small polygamous cymes.

3. URTICACEÆ.

Pilea trinervia Wt., a succulent herb, having swollen internodes with opposite serrate leaves, and the lateral nerves being prolonged right into the apex.

4. OPILIACEÆ.

Opilia amentacea Roxb., a partial root-parasitic shrub with succulent habit and alternate leaves, flowers in bracteate racemes and free petals; fruits glaucous green drupes.

Cansjera Rheedii Gmel., a climbing shrub with recurved thorns on the lenticillate branches, flowers in spikes, petals combined in gamopetalous

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corolla; drupe smooth, orange red. The plants can often be located by the dense, dark hairy growth of *Meliola Cansjericola* Hansford and Thirum.

5. LORANTHACEÆ.

Elytranthe capitellata Engler, a parasitic shrub, with the flower tube white, lobes reflexed, changing to red, and having purple lines.

6. ARISTOLOCHIACEÆ.

Aristolochia indica L., a twiner; leaves upto 6″ long, 3″ broad, sub-panduræform; flowers with greenish-white tube, the lip dark and oblong, stigmatic lobes incurved; seeds winged.

A. bracteata Retz., a perennial climber with broadly ovate, glaucous leaves upto 3″ and having solitary flowers with greenish tube and dark purple lip.

7. POLYGONACEÆ.

Polygonum plebegum R. Br., a prostrate herb with flat branches and pink flowers.

8. AMARANTHACEÆ.

Celosia argentea Linn., a slender annual with shining and conspicuous flower heads. Perianth white or rose coloured.

Aerua lanata Juss., a branched undershrub, with axillary spikes and alternate leaves which are pubescent above and white woolly beneath.

9. BASELLACEÆ.

Basella rubra Linn., a succulent herb with white or red flowers in spikes, having fleshy peduncles.

10. LEGUMINOSÆ.

Dicrostachys cinerea W. and A., a shrub with thorny branches and bipinnate pubescent leaves; flowers in spikes which are cylindric; upper flowers hermaphrodite, yellow, lower ones neuter with pink filiform stamens.

Pterolobium indicum A. Rich., a straggling shrub with recurved thorns, having yellow flowers and reddish winged pods.

Tephrosia tinctoria Pers., a pretty shrub with golden-brown pubescence; leaflets 1–13, parallel nerved, terminal one being the longest; flowers red, A–10, diadelphous; stigma penicillate.

Aeschynomene indica Linn., a slender undershrub with woody stem found in marshy situations, with numerous minute leaflets and viscid inflorescence; stamens diadelphous, 5 + 5; fruit a lomentum.

11. OXALIDACEÆ.

Oxalis latifolia H. B. and K., a runner with trifoliate leaves and reddish flowers.

12. RUTACEÆ.

Atalantia monophylla Correa., a small thorny tree, with alternate unifoliolate leaves; flowers in clusters; fruit a large subglobose berry with 1 to 5 seeds.

13. EUPHORBIACEÆ.

Fluggea leucopyrus Willd., a straggling shrub; with spiny branchlets, the white fruit separating into two-valved cocci.

Emblica officinalis Gaertn., a small tree with light-green exfoliating bark; the branches and rhachis villous; the edible fruits are fleshy and rounded.

Breynia patens Rolfe., a shrub reaching 4 feet, and having small axillary diœcious flowers; fruits are dehiscent and orange-red in colour.

14. RHAMNACEÆ.

Scutia myrtina Kurz., a thorny scrambler, with small obovate shining leaves; deep purple ovoid drupe having two to four crustaceous seeds.

Sageratia parviflora G. Don., a straggling thorny shrub, the thorns straight; leaves penninerved, with 6 pairs of main nerves; stipules minute, deciduous. K (5), C 5 clawed, A 5, $\underline{G}$ 3, stigmas capitate and fruits globose.

15. VITACEÆ.

Tetrastigma sulcatum Gamb., a climber with flattened tuberculate stem and pedately five foliolate leaves; flowers in axillary cymes covered with small hairs, stigma four lobed; fruit large green berry.

Ampelocissus latifolia Planch., a slender climber with cymose inflorescence and tendrils on peduncles; the young shoots and inflorescence pubescent.

16. MALVACEÆ.

Sida glutinosa Cav. = *S. mysorensis* W. and A., a pubescent weed with simple or stellate hairs and solitary axillary flowers having a yellow corolla, staminal tube divided into numerous filaments at the top; fruits enclosed in calyx, carpels separating.

17. FLACOURTIACEÆ.

Flacourtia sepiaria Roxb., a small thorny shrub, with obovate leaves and flowers usually on thorns; K 4–5, C O, A ∞, with versatile anthers; fruit an indehiscent berry.

18. LYTHRACEÆ.

Rotala densiflora Koehne., a herb of marshy places reaching 6–12 inches high, with many divaricating floriferous branches; flowers rose coloured, opposite to leaves; and fruits septicidal capsules.

19. OENOTHERACEÆ.

Ludwigia parviflora Roxb., an erect herb in marshy habitat with lanceolate leaves and yellow flowers; ovary inferior, 4 to 5 celled and developing into an inflated capsule.

20. PRIMULACEÆ.

Anagallis pumila Swartz., small erect annual weed with angular stems which are somewhat winged; flowers solitary, axillary, white, K (5), C 5, A 5, $\underline{G}$ (5); fruit a circumscissile capsule.

21. OLEACEÆ.

Jasminum rigidum Zenk., a rigid shrub with shining leaves, white flowers and small subglobose carpels.

Jasminum Sambac Ait., an erect or climbing shrub with pubescent branchlets and fragrant flowers; cultivated.

22. ASCLEPIADACEÆ.

Hemidesmus indicus R. Br., a twining shrub with polymorphous leaves and flowers small, greenish-purple in crowded cymes; follicles long and elongated.

Sarcostemma brevistigma W. and A., a leafless jointed trailing shrub with succulent stem, growing on rocks and bushes; flowers in terminal umbels.

Asclepias curassavica L., an erect herb with narrowly lanceolate leaves, and bright orange-red flowers; an introduced plant which has now run wild.

23. CONVOLVULACEÆ.

Merremia emarginata Hall f., a creeping herb, rooting at nodes, with yellow flowers and small globose capsules; found in damp places.

24. BORRAGINACEÆ.

Ehretia microphylla Lamk., a small shrub with fascicled very coriaceous small leaves which are covered on the upper surface with large white glands each with a bristle; flowers small with bipartite style; and scarlet globose drupes.

25. VERBENACEÆ.

Lantana aculeata Linn., a straggling shrub with many recurved prickles, and red flowers.

26. SCROPHULARIACEÆ.

Bacopa Monnieri (L) Pennell., a succulent creeping herb, rooting at nodes, and with simple leaves; flowers bluish, calyx bilabiate, stamens 4 didynamous, cells of the anthers contiguous; capsules ovoid with indefinite seeds.

Striga lutea Lour., an erect hirsute parasitic herb, with linear leaves, and flowers with white or yellow corolla.

26 *a*. ACANTHACEÆ.

Thunbergia alata Bojer., a slender climber with axillary flowers which are yellow with purple-brown or claret-coloured throat; petioles winged; calyx annular; fruit capsule, ovules two in each cell, without retinacula.

Dyschoriste depressa Nees., a trailing perennial herb, often rooting at nodes; leaves shortly dentate; K (5), C 5 obscurely two lipped, twisted to left in bud; A 4, anthers minutely mucronate at base, $\underline{G}$ (2); flowers violet pink; fruit a capsule, solid at the base.

Peristrophe bicalyculata Nees., a spreading herb with angular hispid stems, and lax panicles; bracts 2, opposite; corolla pinkish, and two pubescent stamens; capsule four seeded, the seeds glochidiate papillose.

Adhatoda vasica Nees., a dense shrub with fœtid smell, the flowers white with the throat barred with red or yellow; flowers in thyrsoid spikes, bracts greenish; anther cells not appendaged as in *Justicia*.

27. RUBIACEÆ.

Plectronia parviflora Bedd., a thorny shrub with small white flowers, tetramerous, in axillary cymes; corolla tube short with reflexed hairs within; fruit a 2-seeded drupe.

Pavetta indica L., a small tree, with the stipules connate in loose deciduous sheath; leaves with bacterial nodules; flowers in corymbose cymes; corolla twisted in bud; style entire; fruit 2-seeded fleshy berry.

28. GRAMINEÆ.

Imperata cylindrica Beauv., perennial herbs with solid culms which are 1–4 feet high; leaves 5 to 7 cm. by 5 mm.; inflorescence cylindrical, white silky hairy. (Cotton grass).

Ischæmum aristatum Linn., perennial herbs; leaves convolute when young, ultimately flat; 10–25 by 0·6–2·5 cm.; linear lanceolate, sparsely hairy, subcordate base and scabrid margins; ligule membraneous, 1–1·5 mm.; inflorescence of twin spiciform racemes; flowers awned.

Dichanthium annulatum Stapf., perennial, densely tufted herbs, with stems erect or ascending, nodes usually bearded, and alternately flattened; leaves 7·5 to 30 cm. by 3 to 6 mm., sheaths bearded at the tip; ligule membraneous, oblong, 2–4 mm., decurrent; racemes fascicled, spikelets in pairs, flowers awned.

D. caricosum A. Camus., same as above; leaves 15–20 cm. by 2·5 to 5 mm.; ligule a short ciliate membrane; spiciform racemes 2 to 4 nate.

Amphilophis pertusa Stapf., perennial; leaves upto 30 cm. by 3–4 mm.; lower ones crowded at the base of the stem; sheaths terete; ligule truncate, ciliate; racemes 3–8 digitately fasciculate. A good fodder grass.

Heteropogon contortus Beauv., ex Roem et Schult., a perennial, densely tufted; leaves 15 to 30 cm. by 2·5 to 5 mm. often ciliate at the base; sheath compressed, shortly auricled; ligule short, truncate, ciliolate; all awns of a raceme twisted about each other.

Themeda triandra Forsk., a densely tufted perennial; leaves 7·5 to 20 cm. by 2·5 to 5 mm.; ligule a narrow ciliolate membrane; panicles narrow, solitary or two to three branched, bearing dense fascicles of racemes, some of the spikelets bearded with coloured hairs. A common species covering large patches of ground to the exclusion of all other small plants.

Iseilema laxum Hack., a perennial from a creeping root-stock; leaves all cauline, or the lower ones radicle with equitant sheaths, 7·5 to 15 cm. by 1·2 to 3 mm.; sheaths lax; ligules short and truncate; panicle racemiform with distant axillary fascicles.

Cymbopogon cæsius Stapf., a tufted perennial with intra- or extravaginal innovation shoots from a short rhizome; branches often in fascicles; leaf-blades tapering to a long setaceous point; sheaths firm, tight; inflorescence of paired racemes, one sessile, the other peduncled.

C. citratus Stapf., a tall perennial throwing dense fascicles of leaves from a short branched rhizome; leaf-blade tapering as in above, aromatic; sheaths terete.

C. Martinii Wats., a perennial sweet scented grass; stem glabrous, straw coloured.

Hemarthria compressa Kunth., a perennial with compressed culms; leaves upto 15 cm. by 5 to 8 mm.; branches in fascicles; leaf bases rounded, margins scabrid; a hygrophilous species.

Digitaria longiflora Pers., annual or perennial; stems many, tufted, creeping and rooting; leaves 1·3 to 10 cm., stiff and pungent, sheaths smooth or hairy; spikes 2–5 terminal.

Alloteropsis cimicina Stapf., a tufted species with hairy nodes; leaves 2·5 to 7·5 cm. by 10 to 16 mm., ciliate on the margins with stiff bulbous based hairs; inflorescence in spikelike racemes, 3 to 10 on top of a slender peduncle.

Braçhiaria distachya Stapf., a slender grass, culms angular, hairy at the nodes, chanelled; leaves 5–15 cm. by 3–16 mm., widest at the rounded or amplexicaul base; sheaths ciliate or not, mouths hairy; 2 to 4 spikelets; a subgregarious species.

Paspalum Scrobiculatum Linn., an annual with tufted stem on a short rhizome, leafy from the base upwards; leaves bifarious, 15 to 45 cm. by 2 to 8 mm.; spikes 2 to 6 sessile; grain is used as a food.

Paspalidium geminatum Stapf., perennial from a short creeping base; leaves 10 to 20 cm. by 6 to 10 mm., margins often incurved; sheaths large and loose, ligule a ridge of hairs; growing usually in marshy places.

Echinochloa Crus-Galli Beauv., an annual with geniculately ascending stem; leaf narrowed to an acute point, 7 to 25 cm. by 6 to 12 mm., margins finely cartilagenous; sheaths somewhat loose, often compressed; ligule 0; spikes with few to 15 branches which are distantly placed; spikelets crowded, awned; a marshy plant.

Oplismenus compositus Beauv., a tall branching grass, branches rooting from the lower nodes; leaves 5 to 15 cm. by 13 to 20 mm., hairy to velvety below, bases auricled on one side, sheaths with ciliate margins; nodes pubescent; awns pubescent, smooth and obtuse; grows in shade.

Panicum miliaceum Willd., an annual, softly hirsute below the nodes; leaf-blade long, 30 to 50 cm. by 1 to 2·5 cm., tapering to a slender point; principal nerves 5 to 11, the median being the most distinct; sheaths striate;

spreadingly hirsute with tubercle-based hairs; ligule a narrow ciliate rim; panicles contracted.

P. repens Linn., the Ginger grass. A perennial with distichous leaves, and culms creeping at the base, stoloniferous; sterile shoots closely leafy; leaves 5 to 15 cm. long; sheaths with ciliate margins, ligule a hair ring.

P. trypheron Schult., annual with leaves usually basal only, copiously hairy from tubercles; 7·5 to 25 cm. by 4 to 6 mm. margins almost smooth; ligule short, fimbriate; inflorescence erect.

Dactyloctenium ægyptium Beauv., an annual; stems sometimes prostrate, rooting from the proliferately branched nodes; leaves linear 2·5 to 12·5 cm. by 2 to 4 mm., tapering to a fine point; ligule a slightly ciliolate line; spikes 2 to 6, digitately radiating. A very nutritious fodder grass.

Saccolepis interrupta Stapf., a glabrous perennial ascending from a creeping and rooting or floating rootstock; leaves 15 to 30 cm. by 6 to 13 mm., linear, finely acuminate, base rounded or subcordate; ligule broad and membraneous, spike-like panicles, cylindric, interrupted below. Inhabits swampy places.

Setaria verticillata Beauv., an annual; leaves 4 to 20 mm., linear or linear lanceolate, tapering to a fine point; base usually narrow, sheaths smooth, striate, ligule a fringe of hairs.

Pennisetum Hohenackeri Hochst. = *P. Alopecuros* Nees., a perennial growing in marshy places, densely tufted below; branches erect; leaves 30 to 45 cm. by 2·5 to 4 mm., convolute, with a tuft of hairs at the base; ligule a small hairy ring.

Isachne dispar Trin., a troublesome weed in wet situations; erect from a rooting base; leaves 3 to 6 cm. by 0·5 to 1 mm.

Arundinella setosa Trim., perennial, erect from a hard rootstock, nodes glabrous; leaves 15–30 cm. by 3 to 6 mm., finely pubescent or sometimes hispidly hairy; ligule very small; panicles lax, branched.

Aristida adscencionis L., a slender tufted herb, culms upto two feet high; leaves 25 to 60 cm. long; sessile awns and muticous glumes being present; ligule a ridge of soft hairs.

A. Hystrix Linn., a perennial, with diffuse stem from a creeping rootstock; leaves glaucous, 3·8 to 10 cm. by 1·6 to 3·2 mm. convolute; sheaths glabrous, striate; ligule of soft hairs; long panicle many branched; spikelets with three prominent awns from the floral glume.

A. setacea Retz., perennial with smooth or polished branches, leaves 15 to 30 cm. by 2 to 4 mm., usually convolute; sheath long and smooth; panicle open or contracted; three awned as above.

Trachys muricata Steud., a diffuse softly villous annual, with ovate lanceolate leaves, and villous nodes; leaves 2·5 to 10 cm. by 6 to 13 mm., softly villous on both surfaces, margins crisped, base rounded; sheaths glabrous or hairy; ligule a thin membrane; spikelets subglobose.

Tragus biflorus Schult., a tufted annual, simple or branched; branches often densely leafy; nodes glabrous; leaves variable in length, with pectinately ciliate margins; lowermost sheaths short, intermediate ones more or less herbaceous, uppermost tumid, usually embracing the base of the panicles; ligule a slender ciliate rim; spikelets 2, facing each other, with echinate glumes.

Sporobolus diander Beauv., perennial; leaves 10 to 25 cm. by 1 to 1·6 mm., with filiform tips, strongly nerved; ligule a ridge of minute hairs; panicle loosely branched, the spikelets racemosely arranged along the branchlets.

Eragrostis cilianensis Link., a perennial with culms 25 to 90 cm. high; leaves with glandular margins and scattered spikelets.

E. tenuifolia Hochst., perennial; leaves 5 to 25 cm. by 3 to 5 mm., very narrow; mouth of sheath naked; panicle oblong to ovate, very open; branches solitary or 2-nate, distant.

E. riparia Nees. = *E. tenella* Beauv. var *riparia*, perennials; with wiry culms, leaves often at right angles to the culm; sheaths long, ciliate near the mouth.

Cynodon dactylon Pers., a perennial glabrous species; stem slender, prostrate, widely creeping, with 4 to 6 erect flowering branches; the common grass; propogates by its rhizomes and stolons; grows everywhere abundantly, and flowers throughout the year.

Chloris barbata Sw., perennial with tufted stem, with geniculately ascending upward branches; lower internodes shining, upper very long, slender; nodes often bearing equitant tufts of leaves; leaves 15 to 45 cm. long, flat or folded; ligule a very narrow membrane; spikes 5 to 20, digitately arranged in a truncate fascicle, on a slender peduncle, often purplish; awns of flowering glumes with densely bearded margins above the middle.

Eleusine coracana Gaertn., an annual with erect tufts; leaves distichous, often far overtopping the stem; sheaths compressed, loose; ligule of hairs. Cultivated for the edible grain, Ragi. It is a cultivated form of *E. indica* Gaertn.

29. CYPERACEÆ.

Kyllinga triceps Rottb., annual week stemmed herb, 3 to 10 inches high; leaf from half to as long as the stem; heads usually three, cylindric, ovoid, pale; nutlet yellow-brown.

Cyperus compressus L., perennial marshy herbs with the stems tufted with a silvery green sheen; spikelets strongly compressed, 20 to 60 flowered; nuts trigonous, broadly obovoid.

C. rotundus Linn, a perennial with subsolitary stems, trigonous, 4 to 48 inches high; leaves numerous, bracts usually three, upto 2 feet long; compound umbel; nut trigonous, greyish-black. A troublesome weed, difficult to eradicate.

Fimbristylis dichotoma Vahl., herbs with fibrous roots; stems 1 to 10 inches high; leaves shorter, narrow, more or less pubescent; compound umbels with the glumes spirally disposed; bracts pubescent; nuts trabeculate.

F. monostachya Hassk., rhizomatous tufted herbs, with angled stem, 2 to 18 inches high; leaves chanelled, smooth, sheaths membraneous; glumes distichous, coriaceous, strongly cuspidate, the empty basal ones often aristate; nut pear-shaped with a distinct stalk.

Bulbostylis barbata Kunth., tufted annuals with slender striate stems 2 to 12 inches high; leaf-sheaths pilose; bracts three, shorter than the head; spikelets few to many in dense terminal globose heads; glumes laterally compressed; nut broadly ovoid, obtusely trigonous, straw coloured.

30. LEMNACEÆ.

Lemna polyrrhiza Linn., found in still waters; has several tufted rootlets from the lower surface of the frond; fronds often purple below.

31. ERIOCAULACEÆ.

Eriocaulon Sieboldianum Sieb and Zucc., marshy plants with short stems, with capillary or very narrowly long linear leaves; plants and involucral bracts glabrous; bracts hyaline, shiny, often with a purplish central zone.

E. quinquangulare Linn., marsh herbs as above; involucral bracts not longer than the floral bracts and the flowers; leaves linear-ensiform, 5–11 nerved, purplish beneath, often drying red; heads globose ovoid, grey or snow white.

32. LILIACEÆ.

Chlorophytum attenuatum Bak., perennial herbs with the roots fascicled, tuber-like; leaves radical, not falcate, 7–18 inches long, slightly narrowed

at the base; flowers in simple or shortly branched dense flowered racemes; scapes naked; pedicels jointed about the middle; perianth segments 3–5 nerved; anthers longer than the filaments.

Scilla indica Bak., scapigerous herb with tunicate bulb; leaves linear, narrowed into a sheathing petiole, dark green above; scape 2–6 inches long; flowers greenish purple.

33. AMARYLLIDACEÆ.

Crinum asiaticum Linn., stout herbs with bulbous rootstock; perianth salver shaped, erect, lobes linear, tubes 3 to 4 inches long; fruit 1 to 2 inches in diameter.

C. latifolium L., stout herb as above, with the perianth funnel shaped, drooping, lobes lanceolate 3–4 inches long; fruit 1·5 to 2·5 inches in diameter.

Curculigo orchioides Gaertn., stemless herbs with tuberous rootstock; leaves sessile, glabrous, wide; scape usually very short and hidden among the bases of the leaves underground, only the perianth rising not far above the ground.

Zephyranthes sp. ?

34. DIOSCOREACEÆ.

Dioscorea bulbifera Linn., climbing tuberous herbs; stems unarmed, bearing bulbils in the leaf axils; leaves with cordate base, 2–8 inches long.

D. pentaphylla Linn., climbers as above with oblong tubers; stem slender, prickly towards the base; leaves rusty hairy, leaflets 3–5, petioles 2 to 5 inches long.

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